DRISI

Caltrans Division of Research,
Innovation and System Information

Research Results

Constructing Bridge Piers More Rapidly with Improved Seismic Performance

Using concrete-filled tube columns for bridge piers to reduce construction time, lower costs, and enhance seismic performance

Seismic

MARCH 2013

Project Title:
Rapid Construction of Bridge Piers with Improved Seismic Performance

Task Number: 1972
Completion Date: September 30, 2012

This project investigated the performance of concrete-filled tube (CFT) columns for bridge construction and developed designs for simple and economical column-to-footing connections.

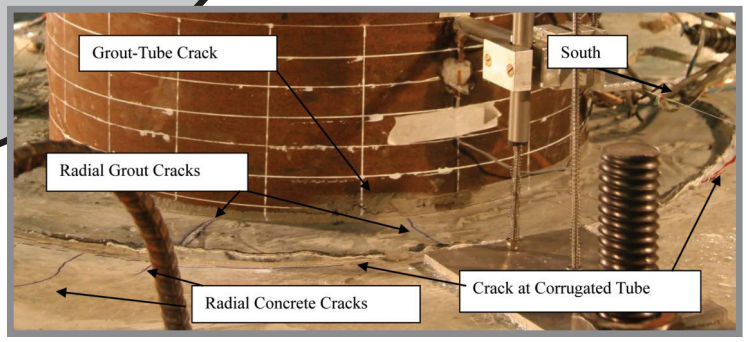
Task Manager:
Peter Lee,
Research Contract Manager
peter.s.lee@dot.ca.gov

WHAT WAS THE NEED?

Bridge construction requires practical methods that allow for rapid and efficient construction. When construction proceeds slowly, costs increase, traffic and commerce are interrupted, and workers are exposed to greater risk of injury. In high-seismic areas, adherence to strict engineering performance requirements must also be considered. Concrete-filled tube (CFT) bridge piers can meet these diverse requirements.

CFTs not only promote economical and rapid construction, but also offer increased strength and stiffness compared to structural steel and reinforced concrete, allowing smaller sections to be used. CFTs eliminate the time and costs associated with column formwork and reinforcing cage construction. They can also employ modern, self-consolidating concretes, further reducing labor and construction time.

CFT components encourage the optimal behavior of the concrete and steel. The steel tube serves as formwork and reinforcement to the concrete fill. The fill increases the compressive strength and stiffness, delays and restrains local buckling of the tube, and enhances ductility and resistance if composite action is achieved. The concrete inside the tube is protected from the environment. Although CFTs offer many practical advantages, few studies have focused on the connections for CFT columns to the footings or cap beams, a critical element of bridge construction. This research investigated and developed design procedures for simple and economical connections of circular CFT piers or columns to reinforced concrete foundations, pile caps, and wide cap beams.



Crack formations on south side of specimens

Caltrans

Caltrans improves mobility across California by performing applied research, developing innovations, and implementing solutions.

Constructing Bridge Piers More Rapidly with Improved Seismic Performance

Research Results

WHAT WAS OUR GOAL?

The goal of this research is to reduce construction time and improve seismic structural performance by exploring the potential of CFT column construction for bridge piers and develop an efficient and effective column-to-footing connection.

WHAT DID WE DO?

The Caltrans Division of Engineering Services, in partnership with the University of Washington Department of Civil and Environmental Engineering, investigated the seismic performance of a new type of bridge pier system constructed using spiral weld steel tubes filled with a low-shrinkage concrete. The research used experimental methods to investigate salient parameters, including the diameter-to-thickness ratio of the steel tube, embedment depth of the steel tube into the adjacent concrete component (foundation element or cap beam), and the type of steel tube. The information was used to develop design expressions for the connection, flexural strength and stiffness, and geometric constraints of the system.

The researchers developed design procedures for simple and economical connections of circular CFT piers to reinforced concrete foundations, pile caps, and wide cap beams. The connection requires no dowels or internal reinforcement to connect the tube to the footing or cap beam. The connection uses an annular ring that is welded to the base of the tube. The ring tube is placed into a void in the concrete footing, which is formed using a corrugated steel pipe. The void between the tube and pipe is filled with a high-strength fiber-reinforced grout. The tube is then filled with a low-shrinkage concrete. The seismic performance of the CFT column and connection assembly was compared to a conventional reinforced concrete column.

WHAT WAS THE OUTCOME?

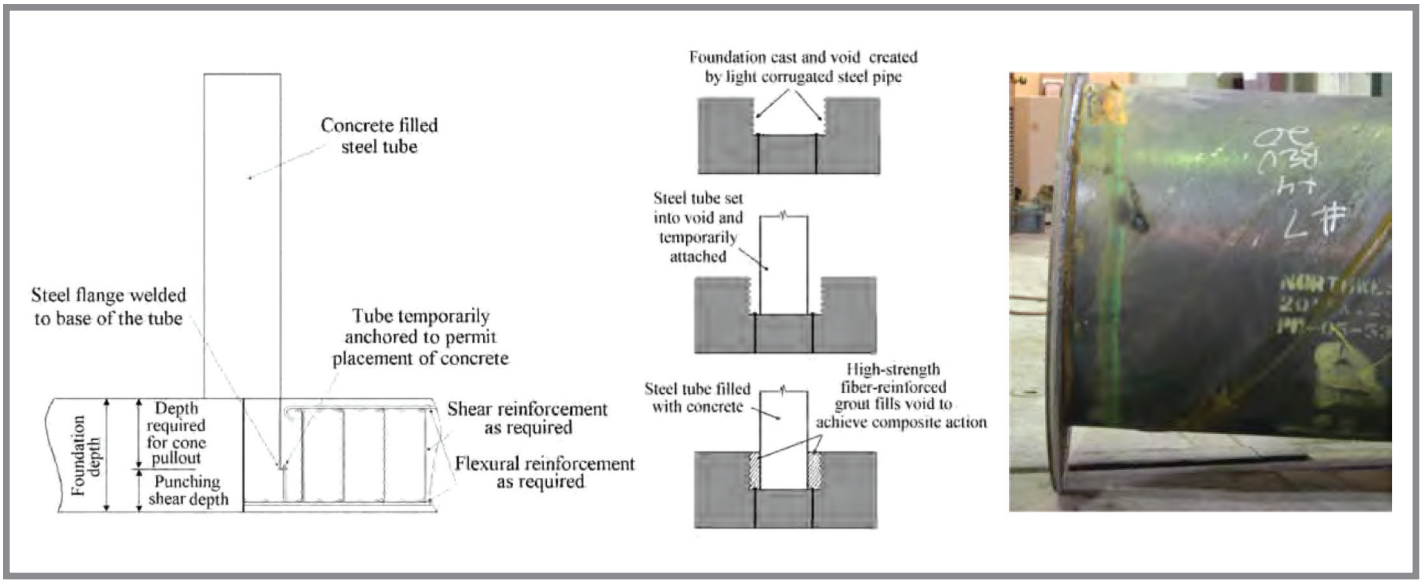
The research showed that the proposed connection develops the full capacity of the composite column, provides excellent ductility, and inelastic deformation capacity under seismic loading while mitigating damage at larger drift demands than the reinforced concrete column.

WHAT IS THE BENEFIT?

CFTs can meet or exceed seismic performance criteria. In addition, they lend themselves to rapid construction and reduced column sizes. As a result, smaller columns can be constructed cheaper and quicker. This is especially important for urban areas such as in Southern California.

LEARN MORE

To view the full report:
www.dot.ca.gov/hq/esc/earthquake_engineering/Research_Reports/vendor/washington/Final%20Report%20CA12-1972%2059A0641.pdf



Construction of a CFT column and connection: (l) Overall configuration; (c) Construction procedure for grouted connection; (r) Welded annular ring at base of tube